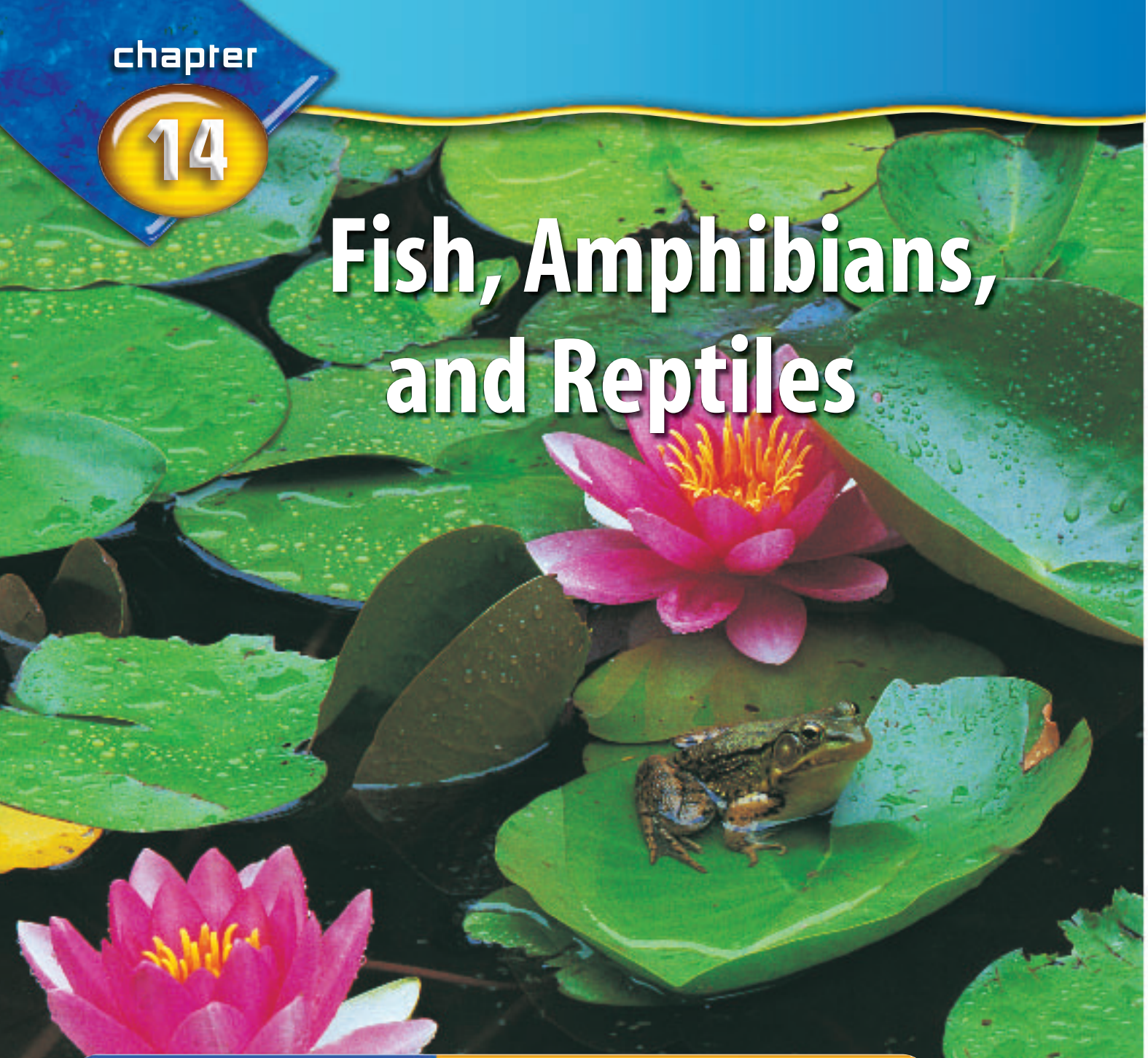
chapter 14

Fish, Amphibians, and Reptiles



chapter preview

sections

1 Chordates and Vertebrates
Lab Endotherms and Exotherms

2 Fish

3 Amphibians

4 Reptiles
Lab Water Temperature and the Respiration Rate of Fish

Virtual Lab How are fish adapted to their environment?

Can I find one?

If you want to find a frog or salamander—two types of amphibians—visit a nearby pond or stream. By studying fish, amphibians, and reptiles, scientists can learn about a variety of vertebrate characteristics, including how these animals reproduce, develop, and are classified.

Science Journal List two unique characteristics for each animal group you will be studying.

Robert Lubeck/Animals Animals

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Start-Up Activities

Launch LAB

Snake Hearing

How much do you know about reptiles? For example, do snakes have eyelids? Why do snakes flick their tongues in and out? How can some snakes swallow animals that are larger than their own heads? Snakes don't have ears, so how do they hear? In this lab, you will discover the answer to one of these questions.

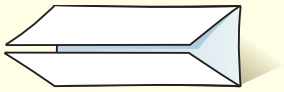
1. Hold a tuning fork by the stem and tap it on a hard piece of rubber, such as the sole of a shoe.
2. Hold it next to your ear. What, if anything, do you hear?
3. Tap the tuning fork again. Press the base of the stem firmly against your chin. In your Science Journal, describe what happens.
4. **Think Critically** Using the results from step 3, infer how a snake detects vibrations. In your Science Journal, predict how different animals can use vibrations to hear.

Science Online — Preview this chapter's content and activities at life.msscience.com

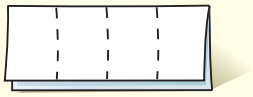
FOLDABLES™ Study Organizer

Fish, Amphibians, and Reptiles Make the following Foldable to help you organize information about the animals you will be studying.

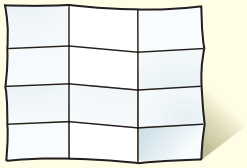
STEP 1 **Fold** one piece of paper lengthwise into thirds.



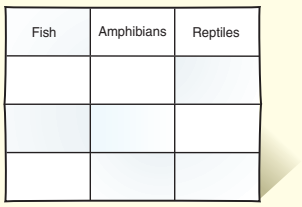
STEP 2 **Fold** the paper widthwise into fourths.



STEP 3 **Unfold,** lay the paper lengthwise, and draw lines along the folds.



STEP 4 **Label** your table as shown.



Make a Table As you read this chapter, complete the table describing characteristics of each type of animal.

Robert Lubeck/Animals Animals

section 1

Chordates and Vertebrates

as you read

What You'll Learn

- **List** the characteristics of all chordates.
- **Identify** characteristics shared by vertebrates.
- **Differentiate** between ectotherms and endotherms.

Why It's Important

Humans are vertebrates. Other vertebrates play important roles in your life because they provide food, companionship, and labor.

Review Vocabulary

motor responses: responses that involve muscular movement

New Vocabulary

- chordate
- notochord
- postanal tail
- nerve cord
- pharyngeal pouch
- endoskeleton
- cartilage
- vertebrae
- ectotherm
- endotherm

Chordate Characteristics

During a walk along the seashore at low tide, you often can see jellylike masses of animals clinging to rocks. Some of these animals may be sea squirts, as shown in **Figure 1,** which is one of the many types of animals known as chordates (KOR dayts). **Chordates** are animals that have four characteristics present at some stage of their development—a notochord, postanal tail, nerve cord, and pharyngeal pouches.

Notochord All chordates have an internal **notochord** that supports the animal and extends along the upper part of its body, as shown in **Figure 2.** The notochord is flexible but firm because it is made up of fluid-filled cells that are enclosed in a stiff covering. The notochord also extends into the **postanal tail**—a muscular structure at the end of the developing chordate. Some chordates, such as fish, amphibians, reptiles, birds, and mammals, develop backbones that partly or entirely replace the notochord. They are called vertebrates. In some chordates, such as the sea squirt, other tunicates, and the lancelets, the notochord is kept into adulthood.

Reading Check *What happens to the notochord as a bat develops?*

Figure 1 Sea squirts get their name because when they're taken out of the ocean, they squirt water out of their body.
Determine *what you have in common with a sea squirt.*

Fred Bavendam/Minden Pictures

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Nerve Cord Above the notochord and along the length of a developing chordate's body is a tubelike structure called the **nerve cord,** also shown in **Figure 2.** As most chordates develop, the front end of the nerve cord enlarges to form the brain and the remainder becomes the spinal cord. These two structures become the central nervous system that develops into complex systems for sensory and motor responses.

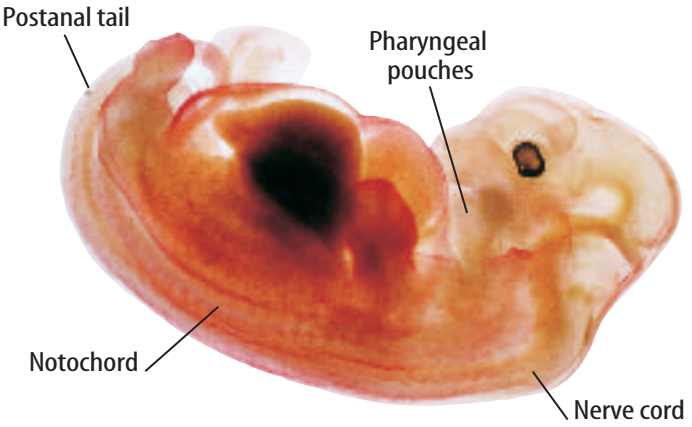


Figure 2 At some time during its development, a chordate has a notochord, postanal tail, nerve cord, and pharyngeal pouches.

Pharyngeal Pouches All developing chordates have **pharyngeal pouches.** They are found in the region between the mouth and the digestive tube as pairs of openings to the outside. Many chordates have several pairs of pharyngeal pouches. Ancient invertebrate chordates used them for filter feeding. This is still their purpose in some living chordates such as lancelets. In fish, they have developed into internal gills where oxygen and carbon dioxide are exchanged. In humans, pharyngeal pouches are present only during embryonic development. However, one pair becomes the tubes that go from the ears to the throat.

Vertebrate Characteristics

Besides the characteristics common to all chordates, vertebrates have distinct characteristics. These traits set vertebrates apart from other chordates.

Structure All vertebrates have an internal framework called an **endoskeleton.** It is made up of bone and/or flexible tissue called **cartilage.** Your ears and the tip of your nose are made of cartilage. The endoskeleton provides a place for muscle attachment and supports and protects the organs. Part of the endoskeleton is a flexible, supportive column called the backbone, as shown in **Figure 3.** It is a stack of **vertebrae** alternating with cartilage. The backbone surrounds and protects the spinal nerve cord. Vertebrates also have a head with a skull that encloses and protects the brain.

Most of a vertebrate's internal organs are found in a central body cavity. A protective skin covers a vertebrate. Hair, feathers, scales, or horns sometimes grow from the skin.

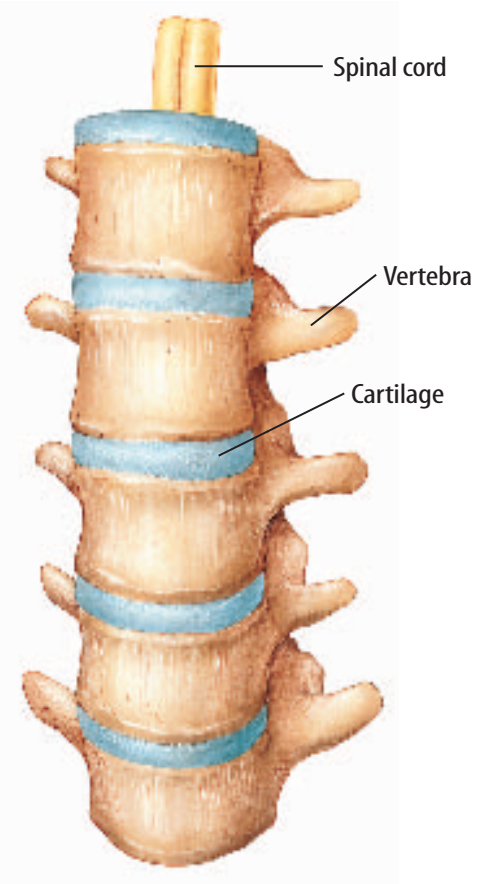
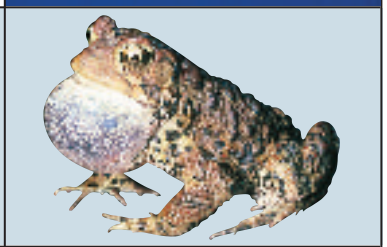


Figure 3 Vertebrae are separated by soft disks of cartilage.

Vertebrae column

Omni-Photo Communications

Table 1 Types of Vertebrates

Group	Estimated Number of Species	Examples	
Jawless fish	60	lamprey, hagfish	
Jawed cartilaginous fish	500 to 900	shark, ray, skate	
Bony fish	20,000	salmon, bass, guppy, sea horse, lungfish	
Amphibians	4,000	frog, toad, salamander	
Reptiles	7,970	turtle, lizard, snake, crocodile, alligator	
Birds	8,700	stork, eagle, sparrow, turkey, duck, ostrich	
Mammals	4,600	human, whale, bat, mouse, lion, cow, otter	

(t to b)(1)H. W. Robison/Visuals Unlimited, (2 3)Flip Nicklin/Minden Pictures, (4)John M. Burnley/Photo Researchers, (5)George Grall/National Geographic Image Collection, (6)M. P. Kahl/DRK Photo, (7)Grace Davies/Omni-Photo Communications

Vertebrate Groups Seven main groups of vertebrates are found on Earth today, as shown in **Table 1.** Vertebrates are either ectotherms or endotherms. Fish, amphibians, and reptiles are ectotherms, also known as cold-blooded animals. An **ectotherm** has an internal body temperature that changes with the temperature of its surroundings. Birds and mammals are endotherms, which sometimes are called warm-blooded animals. An **endotherm** has a nearly constant internal body temperature.

Figure 4 Placoderms were the first fish with jaws. These predatory fish were covered with heavy armor.

Vertebrate Origins Some vertebrate fossils, like the one in **Figure 4,** are of water-dwelling, armored animals that lived about 420 million years ago (mya). Lobe-finned fish appeared in the fossil record about 395 mya. The oldest known amphibian fossils date from about 370 mya. Reptile fossils have been found in deposits about 350 million years old. One well-known group of reptiles—the dinosaurs—first appeared about 230 mya.

In 1861, a fossil imprint of an animal with scales, jaws with teeth, claws on its front limbs, and feathers was found. The 150-million-year-old fossil was an ancestor of birds, and was named *Archaeopteryx* (ar kee AHP tuh rihks).

Mammal-like reptiles appeared about 235 mya. However, true mammals appeared about 190 mya, and modern mammals originated about 38 million years ago.

section 1 review

Summary

Chordate Characteristics

- Chordates have four common characteristics at some point in their development: a notochord, postanal tail, nerve cord, and pharyngeal pouches.

Vertebrate Characteristics

- All vertebrates have an endoskeleton, a backbone, a head with a skull to protect the brain, internal organs in a central body cavity, and a protective skin.
- Vertebrates can be ectothermic or endothermic.
- There are seven main groups of vertebrates.

Self Check

1. **Explain** the difference between a vertebra and a notochord.
2. **Compare and contrast** some of the physical differences between ectotherms and endotherms.
3. **Think Critically** If the outside temperature decreases by 20°C, what will happen to a reptile's body temperature?

Applying Skills

4. **Concept Map** Construct a concept map using these terms: *chordates, bony fish, amphibians, cartilaginous fish, reptiles, birds, mammals, lancelets, tunicates, invertebrate chordates, jawless fish,* and *vertebrates.*

T. A. Wiewandt/DRK Photo

LAB

Endotherms and Ectotherms

Birds and mammals are endotherms. Fish, amphibians and reptiles are ectotherms.

Real-World Question

How can you determine whether an animal you have never seen before is an endotherm or an ectotherm? What tests might you conduct to find the answer?

Goals

- **Construct** an imaginary animal.
- **Determine** whether your animal is an endotherm or an ectotherm.

Materials

fiberfill
**cotton balls*
**old socks*
**tissue*
cloth
thermometer
**Alternate materials*

Safety Precautions

Procedure

1. Design an animal that has a thermometer inside. Construct the animal using cloth and some kind of stuffing material. Make sure that you will be able to remove and reinsert the thermometer.
2. Draw a picture of your animal and record data about its size and shape.
3. Copy the data table in your Science Journal.

4. Place your animal in three locations that have different temperatures. Record the locations in the data table.
5. In each location, record the time and the temperature of your animal at the beginning and after 10 min.

Animal Temperature

Location	Beginning Time/ Temperature	Ending Time/ Temperature
	Do not write in this book.	

Conclude and Apply

1. **Describe** your results. Did the animal's temperature vary depending upon the location?
2. Based on your results, is your animal an endotherm or an ectotherm? Explain.
3. **Compare** your results to those of others in your class. Were the results the same for animals of different sizes? Did the shape of the animal, such as one being flatter and another more cylindrical, matter?
4. Based on your results and information in the chapter, do you think your animal is most likely a bird, a mammal, a reptile, an amphibian, or a fish? Explain.

Communicating Your Data

Compare your conclusions with those of other students in your class. **For more help, refer to the Science Skill Handbook.**

Icon Images

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section 2

Fish

Fish Characteristics

Did you know that more differences appear among fish than among any other vertebrate group? In fact, there are more species of fish than species of other vertebrate groups. All fish are ectotherms. They are adapted for living in nearly every type of water environment on Earth—freshwater and salt water. Some fish, such as salmon, spend part of their life in freshwater and part of it in salt water. Fish are found at varying depths, from shallow pools to deep oceans.

A streamlined shape, a muscular tail, and fins allow most fish to move rapidly through the water. **Fins** are fanlike structures attached to the endoskeleton. They are used for steering, balancing, and moving. Paired fins on the sides allow fish to move right, left, backward, and forward. Fins on the top and bottom of the body give the fish stability. Most fish secrete a slimy mucus that also helps them move through the water.

Most fish have scales. **Scales** are hard, thin plates that cover the skin and protect the body, similar to shingles on the roof of a house. Most fish scales are made of bone. **Figure 5** illustrates how they can be tooth shaped, diamond shaped, cone shaped, or round. The shape of the scales can be used to help classify fish. The age of some species can be estimated by counting the annual growth rings of the scales.

as you read

What You'll Learn

- **List** the characteristics of the three classes of fish.
- **Explain** how fish obtain food and oxygen and reproduce.
- **Describe** the importance and origin of fish.

Why It's Important

Fish are an important food source for humans as well as many other animals.

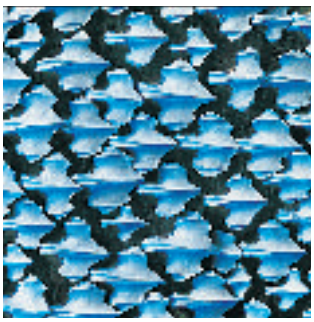
Review Vocabulary

streamline: formed to reduce resistance to motion through a fluid or air

New Vocabulary

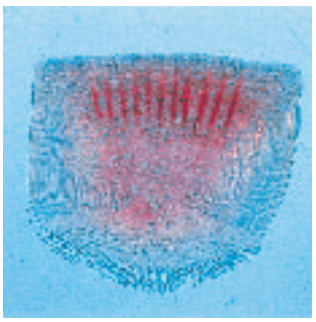
- fin
- scale

Figure 5 Four types of fish scales are shown here.



Sharks are covered with placoid scales such as these. Shark teeth are modified forms of these scales.

Lobe-finned fish and gars are covered by ganoid scales. These scales don't overlap like other fish scales.



Ctenoid (TEN oyd) scales have a rough edge, which is thought to reduce drag as the fish swims through the water.

Cycloid scales are thin and overlap, giving the fish flexibility. These scales grow as the fish grows.

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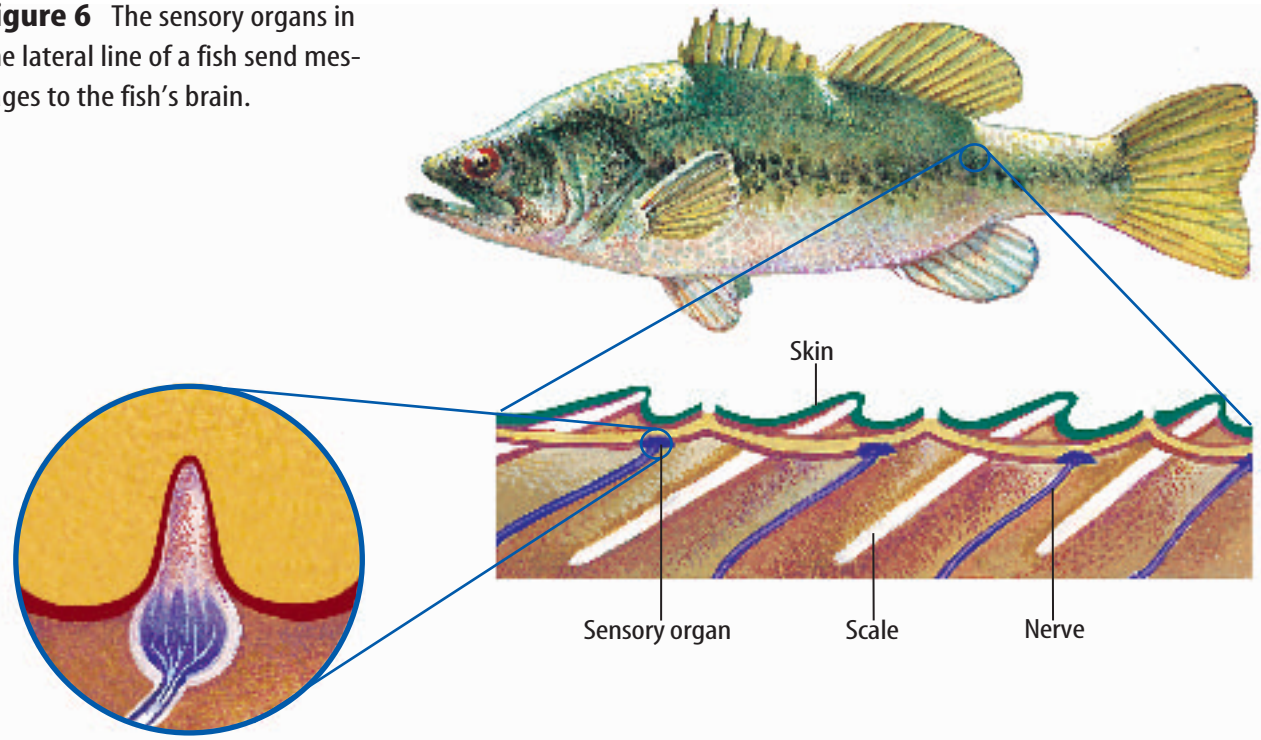
ttav to Researchers, (cl)Rick Gillis/University of Wisconsin-La Crosse, (cr r)Runk/Schoenberger from Grant Heilman

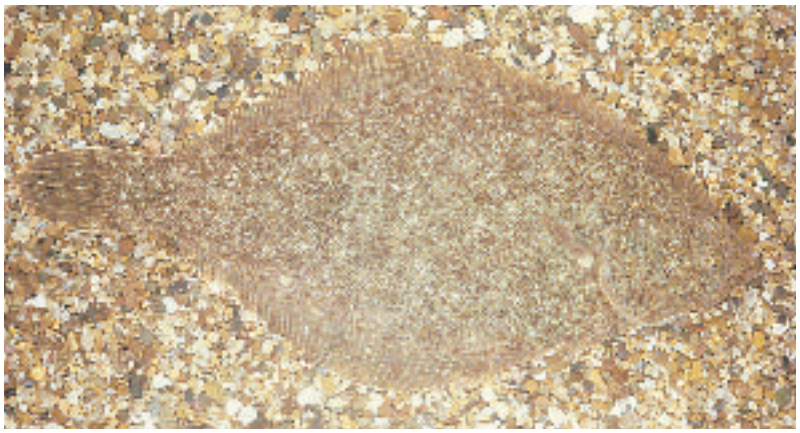
Figure 6 The sensory organs in the lateral line of a fish send messages to the fish's brain.



Body Systems All fish have highly developed sensory systems. Most fish have a lateral line system, as shown in **Figure 6.** A lateral line system is made up of a shallow, canal-like structure that extends along the length of the fish's body and is filled with sensory organs. The lateral line enables a fish to sense its environment and to detect movement. Some fish, such as sharks, also have a strong sense of smell. Sharks can detect blood in the water from several kilometers away.

Fish have a two-chambered heart in which oxygen-filled blood mixes with carbon dioxide-filled blood. A fish's blood isn't carrying as much oxygen as blood that is pumped through a three- or four-chambered heart.

Figure 7 Even though a halibut's eyes are on one side of the fish, gills are on both sides.
Describe *how a fish breathes.*



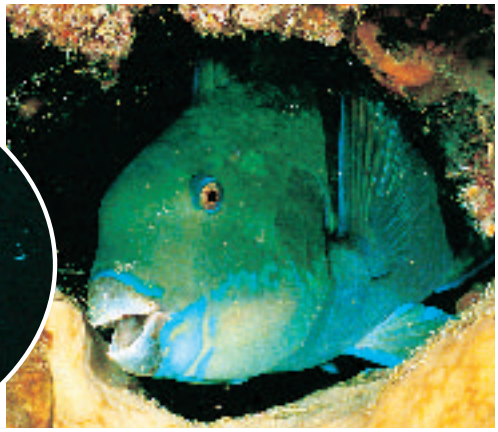
Gas Exchange Most fish have organs called gills for the exchange of carbon dioxide and oxygen. Gills are located on both sides of the fish's head and are made up of feathery gill filaments that contain many tiny blood vessels. When a fish takes water into its mouth, the water passes over the gills, where oxygen from the water is exchanged with carbon dioxide in the blood. The water then passes out through slits on each side of the fish. Many fish, such as the halibut in **Figure 7,** are able to take in water while lying on the ocean floor.

Ken Lucas/Visuals Unlimited

Figure 8 Fish obtain food in different ways.

A whale shark's mouth can open to 1.4 m wide.

Sawfish are rare. They use their toothed snouts to root out bottom fish to eat.



Parrot fish use their hard beaks to bite off pieces of coral.

Electric eels produce a powerful electric shock that stuns their prey.

Feeding Adaptations Some of the adaptations that fish have for obtaining food are shown in **Figure 8.** Some of the largest sharks are filter feeders that take in small animals as they swim. The archerfish shoots down insects by spitting drops of water at them. Even though some fish have strong teeth, most do not chew their food. They use their teeth to capture their prey or to tear off chunks of food.

Reproduction Fish reproduce sexually. Reproduction is controlled by sex hormones. The production of sex hormones is dependent upon certain environmental factors such as temperature, length of daylight, and availability of food.

Female fish release large numbers of eggs into the water. Males then swim over the eggs and release sperm. This behavior is called spawning. The joining of the egg and sperm cells outside the female's body is called external fertilization. Certain species of sharks and rays have internal fertilization and lay fertilized eggs. Some fish, such as guppies and other sharks, have internal fertilization but the eggs develop and hatch inside the female's body. After they hatch, they leave her body.

Some species do not take care of their young. They release hundreds or even millions of eggs, which increases the chances that a few offspring will survive to become adults. Fish that care for their young lay fewer eggs. Some fish, including some catfish, hold their eggs and young in their mouths. Male sea horses keep the fertilized eggs in a pouch until they hatch.

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(tc)Norbert Wu/DRK Photo, (tr)Fred Bavendam/Minden Pictures, (br)Richard T. Nowitz/Photo Researchers

Types of Fish

Fish vary in size, shape, color, living environments, and other factors. Despite their diversity, fish are grouped into only three categories—jawless fish, jawed cartilaginous (kar tuh LA juh nuss) fish, and bony fish.

Jawless Fish

Lampreys, along with the hagfish in **Figure 9,** are jawless fish. Jawless fish have round, toothed mouths and long, tubelike bodies covered with scaleless, slimy skin. Most lampreys are parasites. They attach to other fish with their suckerlike mouth. They then feed by removing blood and other body fluids from the host fish. Hagfish feed on dead or dying fish and other aquatic animals.

Jawless fish have flexible endoskeletons made of cartilage. Hagfish live only in salt water, but some species of lamprey live in salt water and other species live in freshwater.

Jawed Cartilaginous Fish

Sharks, skates, and rays are jawed cartilaginous fish. These fish have endoskeletons made of cartilage like jawless fish. Unlike jawless fish, these fish have movable jaws that usually have well-developed teeth. Their bodies are covered with tiny scales that make their skins feel like fine sandpaper.

Sharks are top predators in many ocean food chains. They are efficient at finding and killing their food, which includes other fish, mammals, and some reptiles. Because of overfishing and the fact that shark reproduction is slow, shark populations are decreasing at an alarming rate.

Reading Check *Why are shark populations decreasing?*

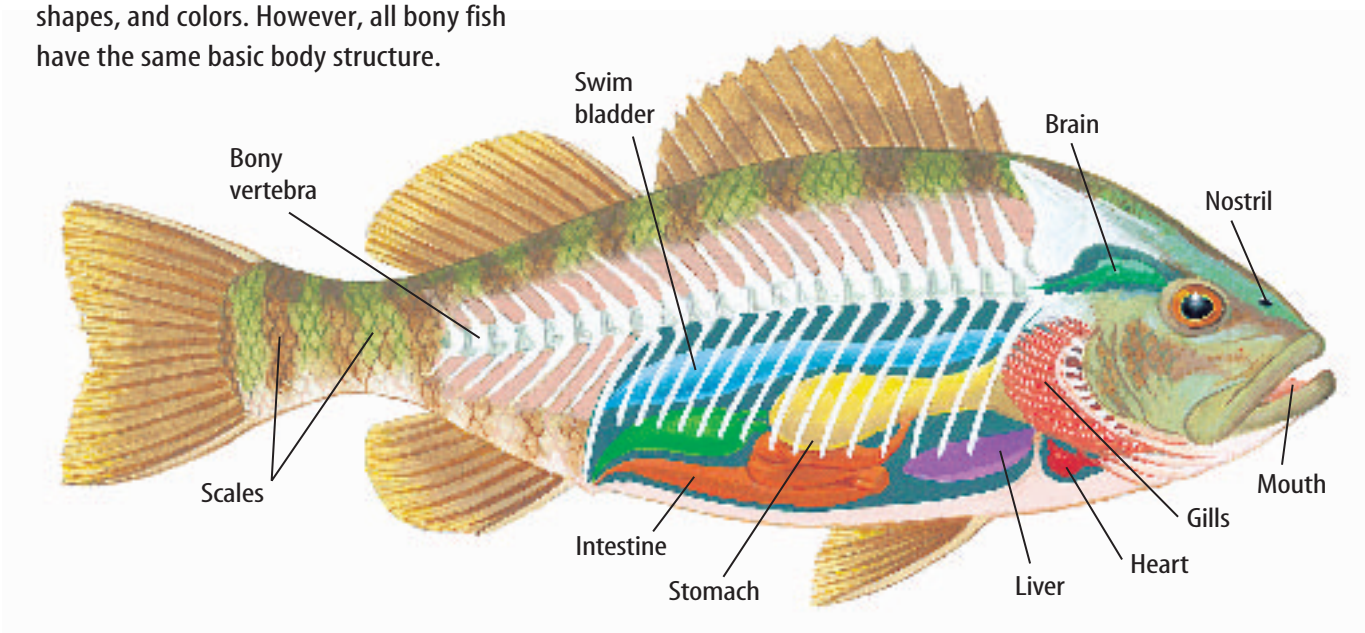
INTEGRATE Health

Fish Fats Many fish contain oil with omega-3 fatty acids, which seems to reverse the effects of too much cholesterol. A diet rich in fish that contain this oil might prevent the formation of fatty deposits in the arteries of humans. In your Science Journal, develop a menu for a meal that includes fish.

Figure 9 Hagfish have cartilaginous skeletons. They feed on marine worms, mollusks, and crustaceans, in addition to dead and dying fish.
Infer *how hagfish eat.*

Tom McHugh/Photo Researchers

Figure 10 Bony fish come in many sizes, shapes, and colors. However, all bony fish have the same basic body structure.



Bony Fish

About 95 percent of all species of fish are bony fish. They have skeletons made of bone. The body structure of a typical bony fish is shown in **Figure 10.** A bony flap covers and protects the gills. It closes as water moves into the mouth and over the gills. When it opens, water exits from the gills.

INTEGRATE Physics

Swim Bladder An important adaptation in most bony fish is the swim bladder. It is an air sac that allows the fish to adjust its density in response to the density of the surrounding water. The density of matter is found by dividing its mass by its volume. If the density of the object is greater than that of the liquid it is in, the object will sink. If the density of the object is equal to the density of the liquid, the object will neither sink nor float to the surface. If the density of the object is less than the density of the liquid, the object will float on the liquid's surface.

The transfer of gases—mostly oxygen in deepwater fish and nitrogen in shallow-water fish—between the swim bladder and the blood causes the swim bladder to inflate and deflate. As the swim bladder fills with gases, the fish's density decreases and it rises in the water. When the swim bladder deflates, the fish's density increases and it sinks. Glands regulate the gas content in the swim bladder, enabling the fish to remain at a specific depth with little effort. Deepwater fish often have oil in their swim bladders rather than gases. Some bottom-dwelling fish and active fish that frequently change depth have no swim bladders.

Mini LAB

Modeling How Fish Adjust to Different Depths

Procedure

1. Fill a **balloon** with air.
2. Place it in a **bowl of water.**
3. Fill **another balloon** partially with water, then blow air into it until it is the same size as the air-filled balloon.
4. Place the second balloon in the bowl of water.

Analysis

1. Infer what structure these balloons model.
2. Compare where in the water (on the surface, or below the surface) two fish would be if they had swim bladders similar to the two balloons.

Try at Home

Figure 11 Coelacanths (SEE luh kanthz) have been found living in the Indian Ocean north of Madagascar.

Lobe-Finned Fish One of the three types of bony fish is the lobe-finned fish, as shown in **Figure 11.** Lobe-finned fish have fins that are lobelike and fleshy. These organisms were thought to have been extinct for more than 70 million years. But in 1938, some South African fishers caught a lobe-finned fish in a net. Several living lobe-finned fish have been studied since. Lobe-finned fish are important because scientists hypothesize that fish similar to these were the ancestors of the first land vertebrates—the amphibians.

Applying Math — Solve a One-Step Equation

DENSITY OF A FISH A freshwater fish has a mass of 645 g and a volume of 700 cm^3. What is the fish's density, and will it sink or float in freshwater?

Solution

1. *This is what you know:*
   - density of freshwater = 1 g/cm^3
   - mass of fish = 645 g
   - volume of fish = 700 cm^3
2. *This is the equation you need to use:*

$$\frac{\text{mass of object (g)}}{} = \text{density of object (g/cm}^3\text{)}$$

3. *Substitute the known values:*

$$\frac{645\ \text{g}}{700\ \text{cm}^3} = 0.921\ \text{g/cm}^3$$

4. *Check your answer:* Multiply 0.921 g/cm^3 by 700 cm^3. You should get 645 g. The fish will float in freshwater. Its density is less than that of freshwater.

Practice Problems

1. Calculate the density of a saltwater fish that has a mass of 215 g and a volume of 180 cm^3. Will this fish float or sink in salt water? The density of ocean salt water is about 1.025 g/cm^3.
2. A fish with a mass of 440 g and a volume of 430 cm^3 floats in its water. Is it a freshwater fish or a saltwater fish?

Science Online — For more practice, visit life.msscience.com/math_practice

Tom McHugh/Photo Researchers

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Figure 12 Australian lungfish are one of the six species of lungfish.
Identify *the unique adaptation of a lungfish.*

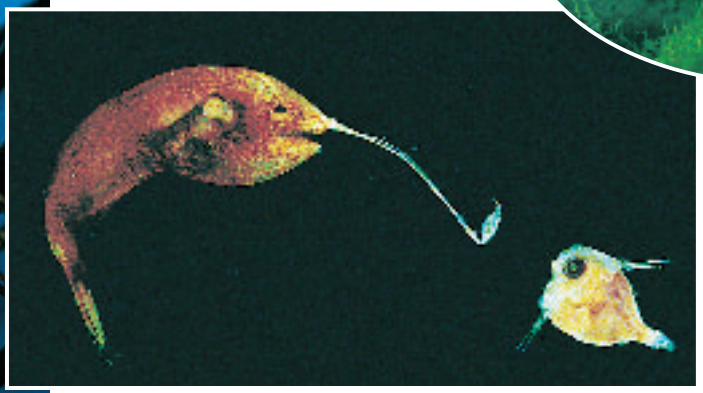
Lungfish A lungfish, as shown in **Figure 12,** has one lung and gills. This adaptation enables them to live in shallow waters that have little oxygen. The lung enables the lungfish to breathe air when the water evaporates. Drought conditions stimulate lungfish to burrow into the mud and cover themselves with mucus until water returns. Lungfish have been found along the coasts of South America and Australia.

Ray-Finned Fish Most bony fish have fins made of long, thin bones covered with skin. Ray-finned fish, like those in **Figure 13,** have a lot of variation in their body plans. Most predatory fish have long, flexible bodies, which enable them to pursue prey quickly. Many bottom fish have flattened bodies and mouths adapted for eating off the bottom. Fish with unusual shapes, like the sea horse and anglerfish, also can be found. Yellow perch, tuna, salmon, swordfish, and eels are ray-finned fish.

Figure 13 Bony fish have a diversity of body plans.

Most bony fish are ray-finned fish, like this rainbow trout.

Sea horses use their tails to anchor themselves to sea grass. This prevents the ocean currents from washing them away.



Anglerfish have a structure that looks like a lure to attract prey fish. When the prey comes close, the anglerfish quickly opens its mouth and captures the prey.

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ari oto Researchers, (bl)Bill Kamin/Visuals Unlimited, (bc)Norbert Wu/DRK Photo, (br)Michael Durham/GLOBIO.org

Figure 14 Lancelets are small, eel-like animals. They spend most of their time buried in the sand and mud at the bottom of the ocean.

Importance and Origin of Fish

Fish play a part in your life in many ways. They provide food for many animals, including humans. Fish farming and commercial fishing also are important to the U.S. economy. Fishing is a method of obtaining food as well as a form of recreation enjoyed by many people. Many fish eat large amounts of insect larvae, such as mosquitoes, which keeps insect populations in check. Some, such as grass carp, are used to keep the plant growth from clogging waterways. Captive fish are kept in aquariums for humans to admire their bright colors and exotic forms.

Reading Check *How are fish helpful to humans?*

Most scientists agree that fish evolved from small, soft-bodied, filter-feeding organisms similar to present-day lancelets, shown in **Figure 14.** The earliest fossils of fish are those of jawless fish that lived about 450 million years ago. Fossils of these early fish usually are found where ancient streams emptied into the sea. This makes it difficult to tell whether these fish ancestors evolved in freshwater or in salt water.

Today's bony fish are probably descended from the first jawed fish called the acanthodians (a kan THOH dee unz). They appeared in the fossil record about 410 mya. Another group of ancient fish—the placoderms—appeared about 400 mya. For about 50 million years, placoderms dominated most water ecosystems then disappeared. Modern sharks and rays probably descended from the placoderms.

section 2 review

Summary

Fish Characteristics

- All fish have a streamlined shape, a muscular tail, fins, scales, well-developed sensory systems, and gills.
- All fish reproduce sexually and feed in many different ways.

Types of Fish

- There are three categories of fish: jawless fish, jawed cartilaginous fish, and bony fish.
- There are three types of bony fish: lobe-finned fish, lungfish, and ray-finned fish.

Self Check

1. **List** examples for each of the three classes of fish.
2. **Explain** how jawless fish and cartilaginous jawed fish take in food.
3. **Describe** the many ways that fish are important to humans.
4. **Think Critically** Female fish lay thousands of eggs. Why aren't lakes and oceans overcrowded with fish?

Applying Skills

5. **Concept Map** Make an events-chain concept map to show what must take place for the fish to rise from the bottom to the surface of the lake.

Runk/Schoenberger from Grant Heilman

section 3

Amphibians

Amphibian Characteristics

The word *amphibian* comes from the Greek word *amphibios,* which means "double life." They are well named, because amphibians spend part of their lives in water and part on land. Frogs, toads, and the salamander shown in **Figure 15** are examples of amphibians. What characteristics do these animals have that allow them to live on land and in water?

Amphibians are ectotherms. Their body temperature changes when the temperature of their surroundings changes. In cold weather, amphibians become inactive and bury themselves in mud or leaves until the temperature warms. This period of inactivity during cold weather is called **hibernation.** Amphibians that live in hot, dry environments become inactive and hide in the ground when temperatures become too hot. Inactivity during the hot, dry months is called **estivation.**

Reading Check *How are hibernation and estivation similar?*

Respiration Amphibians have moist skin that is smooth, thin, and without scales. They have many capillaries directly beneath the skin and in the lining of the mouth. This makes it possible for oxygen and carbon dioxide to be exchanged through the skin and the mouth lining. Amphibians also have small, simple, saclike lungs in the chest cavity for the exchange of oxygen and carbon dioxide. Some salamanders have no lungs and breathe only through their skin.

as you read

What You'll Learn

- **Describe** the adaptations amphibians have for living in water and living on land.
- **List** the kinds of amphibians and the characteristics of each.
- **Explain** how amphibians reproduce and develop.

Why It's Important

Because amphibians are sensitive to changes in the environment, they can be used as biological indicators.

Review Vocabulary

habitat: place where an organism lives and that provides the types of food, shelter, moisture, and temperature needed for survival

New Vocabulary

- hibernation
- estivation

Figure 15 Salamanders often are mistaken for lizards because of their shape. However, like all amphibians, they have a moist, scaleless skin that requires them to live in a damp habitat.

Fred Habegger/Grant Heilman

Figure 16 Red-eyed tree frogs are found in forests of Central and South America. They eat a variety of foods, including insects and even other frogs.

Circulation The three-chambered heart in amphibians is an important change from the circulatory system of fish. In the three-chambered heart, one chamber receives oxygen-filled blood from the lungs and skin, and another chamber receives carbon dioxide-filled blood from the body tissues. Blood moves from both of these chambers to the third chamber, which pumps oxygen-filled blood to body tissues and carbon dioxide-filled blood back to the lungs. Limited mixing of these two bloods occurs.

Reproduction Even though amphibians are adapted for life on land, they depend on water for reproduction. Because their eggs do not have a protective, waterproof shell, they can dry out easily, so amphibians must have water to reproduce.

Amphibian eggs are fertilized externally by the male. As the eggs come out of the female's body, the male releases sperm over them. In most species the female lays eggs in a pond or other body of water. However, many species have developed special reproductive adaptations, enabling them to reproduce away from bodies of water. Red-eyed tree frogs, like the ones in **Figure 16,** lay eggs in a thick gelatin on the underside of leaves that hang over water. After the tadpoles hatch, they fall into the water below, where they continue developing. The Sonoran Desert toad waits for small puddles to form in the desert during the rainy season. It takes tadpoles only two to 12 days to hatch in these temporary puddles.

Figure 17 Amphibians go through metamorphosis as they develop.

After hatching, most young amphibians, like these tadpoles, do not look like adult forms.

Amphibian eggs are laid in a jellylike material to keep them moist.

(t)David Northcott/DRK Photo, (others)Runk/Schoenberger from Grant Heilman

Development Most amphibians go through a developmental process called metamorphosis (me tuh MOR fuh sus). Fertilized eggs hatch into tadpoles, the stage that lives in water. Tadpoles have fins, gills, and a two-chambered heart similar to fish. As tadpoles grow into adults, they develop legs, lungs, and a three-chambered heart. **Figure 17** shows this life cycle.

The tadpole of some amphibian species, such as salamanders, are not much different from the adult stage. Young salamanders look like adult salamanders, but they have external gills and usually a tail fin.

Frogs and Toads

Adult frogs and toads have short, broad bodies with four legs but no neck or tail. The strong hind legs are used for swimming and jumping. Bulging eyes and nostrils on top of the head let frogs and toads see and breathe while the rest of their body is submerged in water. On spring nights, males make their presence known with loud, distinctive croaking sounds. On each side of the head, just behind the eyes, are round tympanic membranes. These membranes vibrate somewhat like an eardrum in response to sounds and are used by frogs and toads to hear.

Most frog and toad tongues are attached at the front of their mouths. When they see prey, their tongue flips out and contacts the prey. The prey gets stuck in the sticky saliva on the tongue and the tongue flips back into the mouth. Toads and frogs eat a variety of insects, worms, and spiders, and one tropical species eats berries.

Science Online

Topic: Biological Indicators
Visit life.msscience.com for Web links to information about amphibians as biological indicators.

Activity What factors make amphibians good biological indicators?

Amphibians go through metamorphosis, which means they change form from larval stage to adult.

Most adult amphibians are able to move about and live on land.

(l)Runk/Schoenberger from Grant Heilman, (r)George H. Harrison from Grant Heilman

Mini LAB

Describing Frog Adaptations

Procedure

1. Carefully observe a **frog** in a **jar.** Notice the position of its legs as it sits. Record all of your observations in your **Science Journal.**
2. Observe its mouth, eyes, nostrils and ears.
3. Observe the color of its back and belly.
4. Return the frog to your teacher.

Analysis

1. Describe the adaptations the frog has for living in water.
2. What adaptations does it have for living on land?

Salamanders

Most species of salamanders and newts live in North America. These amphibians often are mistaken for lizards because of their long, slender bodies. The short legs of salamanders and newts appear to stick straight out from the sides of their bodies.

Land-living species of salamanders and newts usually are found near water. These amphibians hide under leaf litter and rocks during the day to avoid the drying heat of the Sun. At night, they use their well-developed senses of smell and vision to find and feed on worms, crustaceans, and insects.

Many species of salamanders breed on land, where fertilization is internal. Aquatic species of salamanders and newts release and fertilize their eggs in the water.

Importance of Amphibians

Most adult amphibians are insect predators and are helpful in keeping some insect populations in check. They also are a source of food for other animals, including other amphibians. Some people consider frog legs a delicacy.

Poison frogs, like the one in **Figure 18,** produce a poison that can kill large animals. They also are known as poison dart frogs or poison arrow frogs. The toxin is secreted through their skin and can affect muscles and nerves of animals that come in contact with it. Native people of the Emberá Chocó in Colombia, South America, cover blowgun darts that they use for hunting with the poison of one species of these frogs. Researchers are studying the action of these toxins to learn more about how the nervous system works. Researchers also are using amphibians in regeneration studies in hopes of developing new ways of treating humans who have lost limbs or were born without limbs.

Figure 18 Poison frogs are brightly colored to show potential predators that they are poisonous. Toxins from poison frogs have been used in hunting for centuries.

(l)Mark Moffett/Minden Pictures, (r)Michael Fogden/DRK Photo

Biological Indicators Because they live on land and reproduce in water, amphibians are affected directly by changes in the environment, including pesticides and other pollution. Amphibians also absorb gases through their skin, making them susceptible to air pollutants. Amphibians, like the one in **Figure 19,** are considered to be biological indicators. Biological indicators are species whose overall health reflects the health of a particular ecosystem.

Reading Check *What is a biological indicator?*

Figure 19 Beginning in 1995, deformed frogs such as this were found. Concerned scientists hypothesize that an increase in the number of deformed frogs could be a warning of environmental problems for other organisms.

Origin of Amphibians The fossil record shows that ancestors of modern fish were the first vertebrates on Earth. For about 150 million years, they were the only vertebrates. Then as the climate changed and competition for food and space increased, some lobe-finned fish might have traveled across land searching for water as their ponds dried up. Fossil evidence shows that from these lobe-finned fish evolved aquatic animals with four limbs. Amphibians probably evolved from these aquatic animals about 350 mya.

Because competition on land from other animals was minimal, evolution favored the development of amphibians. Insects, spiders, and other invertebrates were an abundant source of food on land. Land was almost free of predators, so amphibians were able to reproduce in large numbers, and many new species evolved. For 100 million years or more, amphibians were the dominant land animals.

section 3 review

Summary

Amphibian Characteristics

- Amphibians have two phases of life—one in water and one on land.
- All amphibians have a three-chambered heart, reproduce in the water by laying eggs, and go through metamorphosis.

Types and Importance of Amphibians

- Frogs and toads have short, broad bodies, while salamanders have long, slender bodies.
- Amphibians are used for food, research, and are important as biological indicators.

Self Check

1. **List** the adaptations amphibians have for living in water and for living on land.
2. **Explain** how tadpole and frog hearts differ.
3. **Describe** two different environments where amphibians lay eggs.
4. **Think Critically** Why do you suppose frogs and toads seem to appear suddenly after a rain?

Applying Skills

5. **Concept Map** Make an events-chain concept map of frog metamorphosis. Describe each stage in your Science Journal.

Rob and Ann Simpson/Visuals Unlimited

section 4

Reptiles

as you read

What You'll Learn

- **List** the characteristics of reptiles.
- **Determine** how reptile adaptations enable them to live on land.
- **Explain** the importance of the amniotic egg.

Why It's Important

Reptiles provide information about how body systems work during extreme weather conditions

Review Vocabulary

bask: to warm by continued exposure to heat

New Vocabulary

- amniotic egg

Reptile Characteristics

Reptiles are ectotherms with a thick, dry, waterproof skin. Their skin is covered with scales that help reduce water loss and protect them from injury. Even though reptiles are ectotherms, they are able to modify their internal body temperatures by their behavior. When the weather is cold, they bask in the Sun, which warms them. When the weather is warm and the Sun gets too hot, they move into the shade to cool down.

Reading Check *How are reptiles able to modify their body temperature?*

Some reptiles, such as turtles, crocodiles, and lizards, like the skink in **Figure 20,** move on four legs. Claws are used to dig, climb, and run. Reptiles, such as snakes and some lizards, move without legs.

Body Systems Scales on reptiles prevent the exchange of oxygen and carbon dioxide through the skin. Reptiles breathe with lungs. Even turtles and sea snakes that live in water must come to the surface to breathe.

The circulatory system of reptiles is more highly developed than that of amphibians. Most reptiles have a three-chambered heart with a partial wall inside the main chamber. This means that less mixing of oxygen-filled blood and carbon dioxide-filled blood occurs than in amphibians. This type of circulatory system provides more oxygen to all parts of the body. Crocodilians have a four-chambered heart that completely separates the oxygen-filled blood and the carbon dioxide-filled blood and keeps them from mixing.

Figure 20 Skinks, like this northern blue-tongue skink, are one of the largest lizard families with around 800 species.

Joe McDonald/Visuals Unlimited

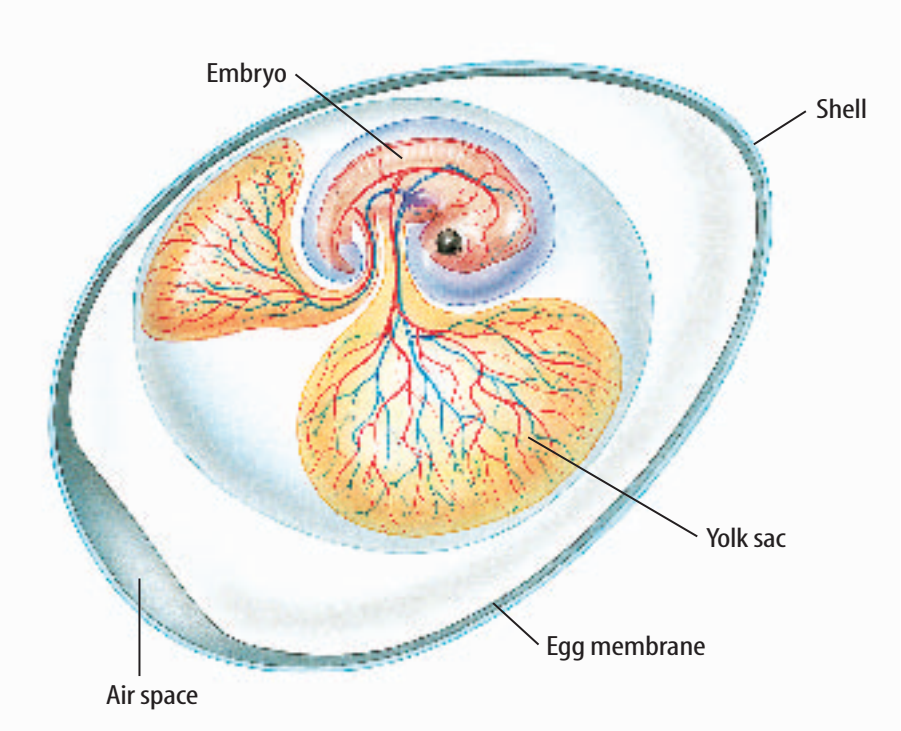

Figure 21 The development of amniotic eggs enabled reptiles to reproduce on land.
Infer *how an amniotic egg helps reptiles be a more successful group.*

Amniotic Egg One of the most important adaptations of reptiles for living on land is the way they reproduce. Unlike the eggs of most fish and amphibians, eggs of reptiles are fertilized internally—inside the body of the female. After fertilization, the females of many reptiles lay eggs that are covered by tough, leathery shells. The shell prevents the eggs from drying out. This adaptation enables reptiles to lay their eggs on land.

The **amniotic egg** provides a complete environment for the embryo's development. **Figure 21** shows the structures in a reptilian egg. This type of egg contains membranes that protect and cushion the embryo and help it get rid of wastes. It also contains a large food supply—the yolk—for the embryo. Minute holes in the shell, called pores, allow oxygen and carbon dioxide to be exchanged. By the time it hatches, a young reptile looks like a small adult.

Reading Check *What is the importance of an amniotic egg?*

Types of Modern Reptiles

Reptiles live on every continent except Antarctica and in all the oceans except those in the polar regions. They vary greatly in size, shape, and color. Reticulated pythons, 10 m in length, can swallow small deer whole. Some sea turtles weigh more than 350 kg and can swim faster than humans can run. Three-horned lizards have movable eye sockets and tongues as long as their bodies. The three living groups of reptiles are lizards and snakes, turtles, and crocodilians.

Science Online

Visit life.msscience.com for Web links to recent news about the nesting sites of turtles.

Activity Name two conservation organizations that are giving the turtles a helping hand, and how they are doing it.

Lizards and Snakes Some animals in the largest group of reptiles—the lizards and snakes like those shown in **Figure 22**—have a type of jaw not found in other reptiles, like the turtle also shown in **Figure 22.** The jaw has a special joint that unhinges and increases the size of their mouths. This enables them to swallow their prey whole. Lizards have movable eyelids, external ears, and legs with clawed toes on each foot. They feed on plants, other reptiles, insects, spiders, worms, and mammals.

Snakes have developed ways of moving without legs. They have poor hearing and most have poor eyesight. Recall how you could feel the vibrations of the tuning fork in the Launch Lab. Snakes do not hear sound waves in the air. They "hear" vibrations in the ground that are picked up by the lower jawbone and conducted to the bones of the snake's inner ear. From there, the vibrations are transferred to the snake's brain, where the sounds are interpreted.

Snakes are meat eaters. Some snakes wrap around and constrict their prey. Others inject their prey with venom. Many snakes feed on small mammals, and as a result, help control those populations.

Most snakes lay eggs after they are fertilized internally. In some species, eggs develop and hatch inside the female's body then leave her body shortly thereafter.

Figure 22 Examples of reptiles are shown below.

When frilled lizards are threatened, they flare out their collar. This behavior helps keep predators away.

Diamondback terrapins are one of the few species of turtles that live in brackish—slightly salty—water.

Rosy boas are one of only two species of boas found in the United States.

(tl)Klaus Uhlenhut/Animals Animals, (tr)Rob & Ann Simpson/Visuals Unlimited, (br)[illegible]

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Turtles The only reptiles that have a two-part shell made of hard, bony plates are turtles. The vertebrae and ribs are fused to the inside of the top part of the shell. The muscles are attached to the lower and upper part of the inside of the shell. Most turtles can withdraw their heads and legs into the shell for protection against predators.

Figure 23 Most turtles are eaten shortly after they hatch. Only a few sea turtles actually make it into the ocean.

Reading Check ***What is the purpose of a turtle's shell?***

Turtles have no teeth but they do have powerful jaws with a beaklike structure used to crush food. They feed on insects, worms, fish, and plants. Turtles live in water and on land. Those that live on land are called tortoises.

Like most reptiles, turtles provide little or no care for their young. Turtles dig out a nest, deposit their eggs, cover the nest, and leave. Turtles never see their own hatchlings. Young turtles, like those in **Figure 23,** emerge from the eggs fully formed and live on their own.

Crocodilians Found in or near water in warm climates, crocodilians, such as crocodiles, gavials, and alligators, are similar in appearance. They are lizardlike in shape, and their backs have large, deep scales. Crocodilians can be distinguished from each other by the shape of their heads. Crocodiles have a narrow head with a triangular-shaped snout. Alligators have a broad head with a rounded snout. Gavials, as shown in **Figure 24,** have a very slender snout with a bulbous growth on the end. Crocodiles are aggressive and can attack animals as large as cattle. Alligators are less aggressive than crocodiles, and feed on fish, turtles, and waterbirds. Gavials primarily feed on fish. Crocodilians are among the world's largest living reptiles.

Crocodilians are some of the few reptiles that care for their young. The female guards the nest of eggs and when the eggs hatch, the male and female protect the young. A few crocodilian females have been photographed opening their nests in response to noises made by hatchlings. After the young hatch, a female carries them in her huge mouth to the safety of the water. She continues to keep watch over the young until they can protect themselves.

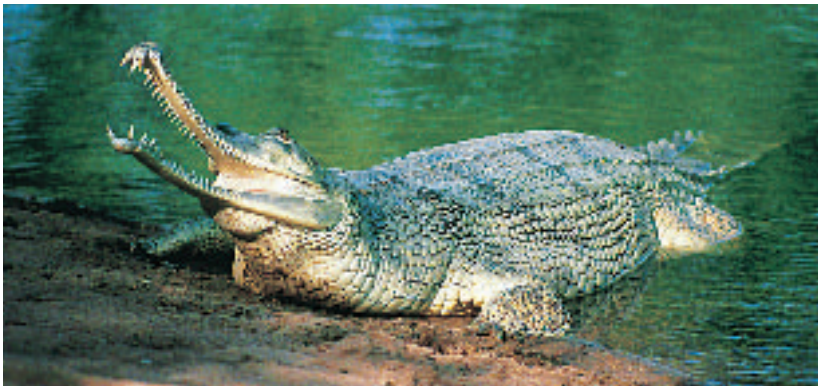

Figure 24 Indian gavials are one of the rarest crocodilian species on Earth. Adults are well adapted for capturing fish.

(t)Mitsuaki Iwago/Minden Pictures, (b)Belinda Wright/DRK Photo

NATIONAL GEOGRAPHIC

VISUALIZING EXTINCT REPTILES

Figure 25

If you're like most people, the phrase "prehistoric reptiles" probably brings dinosaurs to mind. But not all ancient reptiles were dinosaurs. The first dinosaurs didn't appear until about 115 million years after the first reptiles. Paleontologists have unearthed the fossils of a variety of reptilian creatures that swam through the seas and waterways of ancient Earth. Several examples of these extinct aquatic reptiles are shown here.

▲ **MOSASAUR** (MOH zuh sawr) Marine-dwelling mosasaurs had snakelike bodies, large skulls, and long snouts. They also had jointed jawbones, an adaptation for grasping and swallowing large prey.

▲ **ICHTHYOSAUR** (IHK thee uh sawr) Ichthyosaurs resembled a cross between a dolphin and a shark, with large eyes, four paddlelike limbs, and a fishlike tail that moved from side to side. These extinct reptiles were fearsome predators with long jaws armed with numerous sharp teeth.

◀ **ELASMOSAURUS** (uh laz muh SAWR us) Predatory *Elasmosaurus* had a long neck—with as many as 76 vertebrae—topped by a small head.

▲ **CHAMPOSAUR** (CHAM puh sawr) This ancient reptile looked something like a modern crocodile, with a long snout studded with razor-sharp teeth. Champosaurs lived in freshwater lakes and streams and preyed on fish and turtles.

▲ **PLESIOSAUR** (PLEE zee uh sawr) These marine reptiles had stout bodies, paddlelike limbs, and long necks. Plesiousaurs might have fed by swinging their heads from side to side through schools of fish.

(tl)John Sibbick, (tr)Karen Carr, (c)Chris Butler/Science Photo Library/Photo Re[illegible]ner[illegible] The [illegible]ce Museum of Minnesota, (br)Chris Butler

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The Importance of Reptiles

Reptiles are important predators in many environments. In farming areas, snakes eat rats and mice that destroy grains. Small lizards eat insects, and large lizards eat small animals that are considered pests.

Humans in many parts of the world eat reptiles and their eggs or foods that include reptiles, such as turtle soup. The number of reptile species is declining in areas where swamps and other lands are being developed for homes and recreation areas. Coastal nesting sites of sea turtles are being destroyed by development or are becoming unusable because of pollution. For years, many small turtles were collected in the wild and then sold as pets. People now understand that such practices disturb turtle populations. Today most species of turtles and their habitats are protected by law.

Origin of Reptiles Reptiles first appeared in the fossil record about 345 mya. The earliest reptiles did not depend upon water for reproduction. As a result, they began to dominate the land about 200 mya. Some reptiles even returned to the water to live, although they continued to lay their eggs on land. Dinosaurs—descendants of the early reptiles—ruled Earth during this era, then died out about 65 mya. Some of today's reptiles, such as the crocodilians, have changed little from their ancestors, some of which are illustrated in **Figure 25.**

INTEGRATE History

A Changing Environment Dinosaurs, reptiles that ruled Earth for 160 million years, died out about 65 million years ago. In your Science Journal, describe what changes in the environment could have caused the extinction of the dinosaurs.

section 4 review

Summary

Reptile Characteristics

- Reptiles are ectotherms with a thick, dry, waterproof skin that is covered with scales.
- Most have a three-chambered heart with a partial wall in the main chamber.
- Reptile young develop in an amniotic egg.

Types and Importance of Reptiles

- Lizards and snakes are the largest group of reptiles. Most lizards have legs, while snakes do not.
- Turtles have a two-part bony shell.
- Crocodilians are large reptiles and one of the few reptiles that care for their young.
- Reptiles are important predators. Some reptiles are food sources.

Self Check

1. **Describe** reptilian adaptations for living on land.
2. **Explain** how turtles differ from other reptiles.
3. **Infer** why early reptiles, including dinosaurs, were so successful as a group.
4. **Draw** the structure of an amniotic egg.
5. **Think Critically** Venomous coral snakes and some nonvenomous snakes have bright red, yellow, and black colors. How is this an advantage and a disadvantage to the nonvenomous snake?

Applying Math

6. **Solve One-Step Equations** *Brachiosaurus*, a dinosaur, was about 12 m tall and 22 m long. The average elephant is 3 m tall and 6 m long. How much taller and longer is the *Brachiosaurus* compared to an elephant?

LAB

Design Your Own

Water Temperature and the Respiration Rate of Fish

Goals

- **Design** and carry out an experiment to measure the effect of water temperature on the rate of respiration of fish.
- **Observe** the breathing rate of fish.

Possible Materials

goldfish
aquarium water
small fishnet
600-mL beakers
container of ice water
stirring rod
thermometer
aquarium

Safety Precautions

Protect your clothing. Use the fishnet to transfer fish into beakers.

Real-World Question

Imagine that last summer was hot with few storms. One day after many sunny, windless days, you noticed that a lot of dead fish were floating on the surface of your neighbor's pond. What might have caused these fish to die? How does water temperature affect the respiration rate of fish?

Form a Hypothesis

Fish obtain oxygen from the water. State a hypothesis about how water temperature affects the respiration rate of fish.

Test Your Hypothesis

Make a Plan

1. As a group, agree upon and write out a plan. You might make a plan that relates the amount of oxygen dissolved in water at different water temperatures and how this affects fish.

(t)Steve Maslowski/Visuals Unlimited, (b)Michael Newman/PhotoEdit, Inc.

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2. As a group, list the steps that you need to take to follow your plan. Be specific and describe exactly what you will do at each step. List your materials.
3. How will you measure the breathing rate of fish?
4. **Explain** how you will change the water temperature in the beakers. Fish respond better to a gradual change in temperature than an abrupt change. How will you measure the response of fish to changes in water temperature?
5. What data will your group collect? Prepare a data table in your Science Journal to record the data you collect. How many times will you run your experiment?
6. Read over your entire experiment to make sure the steps are in logical order. Identify any constants, variables, and controls.

Follow Your Plan

1. Make sure your teacher approves your setup and your plan before you start.
2. Carry out the experiment according to the approved plan.
3. While the experiment is going on, write down any observations that you make and complete the data table in your Science Journal.

Analyze Your Data

1. **Compare** your results with the results of other groups in your class. Were the results similar?
2. **Infer** what you were measuring when you counted mouth or gill cover openings.
3. **Describe** how a decrease in water temperature affects respiration rate and behavior of the fish.
4. **Explain** how your results could be used to determine the kind of environment in which a fish can live.

Conclude and Apply

1. **Explain** how fish can live in water that is totally covered by ice.
2. **Predict** what would happen to a fish if the water were to become very warm.

Communicating Your Data

Construct a graph of your data on poster board and share your results with your classmates.

KS Studios

TIME SCIENCE AND Society

SCIENCE ISSUES THAT AFFECT YOU!

Venom as Medicine

Hiss, rattle… Run! Just the sound of a snake sends most people on a sprint to escape what could be a painful bite. Why? The bites could contain venom, a toxic substance injected into prey or an enemy. Venom can harm—or even kill—the victim. Some venomous creatures use it to stun, kill, and digest their prey, while others use it as a means of protection.

Venom is produced by a gland in the body. Some fish use their sharp, bony spines to inject venom. Venomous snakes, such as pit vipers, have fangs. Venom passes through these hollow teeth into a victim's body. The Gila monster, the largest lizard in the United States, has enlarged, grooved teeth in its lower jaw through which its venom travels. It is one of only two species of venomous lizards.

Doctors and scientists have discovered a shocking surprise within this sometimes deadly liquid. Oddly enough, the very same toxin that harms and weakens people can heal, too. In fact, doctors use the deadliest venom—that of some pit viper species—to treat certain types of heart attacks. Cobra venom has been used to soothe the effects of cancer, and other snake venoms reduce the spasms of epilepsy and asthma.

Some venoms also contain substances that help clot blood. Hemophiliacs—people whose blood will not clot naturally—rely on the medical benefits that venom-based medicines supply. Venoms also are used in biological research. For instance, venoms that affect the nervous system help doctors and researchers learn more about how nerves function.

It's still smart to steer clear of the rattle or the stinger—but it's good to know that the venom in them might someday help as many as it can hurt.

Research **Besides venom, what other defenses do animals use to protect themselves or to subdue their prey? Explore how some animals that are native to your region use their built-in defenses.**

Science Online

For more information, visit life.msscience.com/time

(tl)Hemera Technologies, Inc., (tc)Michael Fogden/Animals Animals, (tr)Tim h/S v/L Agency

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Reviewing Main Ideas

Section 1 Chordates and Vertebrates

1. Chordates include lancelets, tunicates, and vertebrates. Chordates have a notochord, a nerve cord, pharyngeal pouches, and a postanal tail.
2. All vertebrates have an endoskeleton that includes a backbone and a skull that protects the brain.
3. An endotherm is an animal that has a nearly constant internal body temperature. An ectotherm has a body temperature that changes with the temperature of its environment.

Section 2 Fish

1. Fish are vertebrates that have a streamlined body, fins, gills for gas exchange, and a highly developed sensory system.
2. Fish are divided into three groups—jawless fish, jawed cartilaginous fish, and bony fish.
3. Bony fish, with scales and a swim bladder, have the greatest number of known fish species.

Section 3 Amphibians

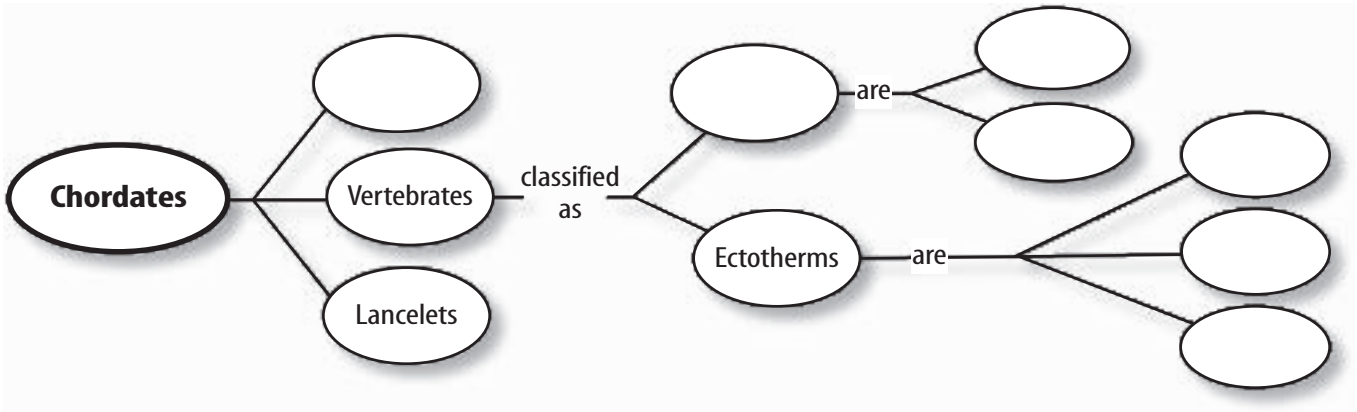
1. The first vertebrates to live on land were the amphibians.
2. Amphibians have adaptations that allow them to live on land and in the water. The adaptations include moist skin, mucous glands, and lungs. Most amphibians are dependent on water to reproduce.
3. Most amphibians go through a metamorphosis from egg, to larva, to adult. During metamorphosis, legs develop, lungs replace gills, and the tail is lost.

Section 4 Reptiles

1. Reptiles are land animals with thick, dry, scaly skin. They lay amniotic eggs with leathery shells.
2. Turtles with tough shells, meat-eating crocodilians, and snakes and lizards make up the reptile groups.
3. Early reptiles were successful because of their adaptations to living on land.

Visualizing Main Ideas

Copy and complete the concept map below that describes chordates.



chapter 14 Review

Using Vocabulary

amniotic egg p. 413	hibernation p. 407
cartilage p. 395	nerve cord p. 395
chordate p. 394	notochord p. 394
ectotherm p. 397	pharyngeal pouch p. 395
endoskeleton p. 395	postanal tail p. 394
endotherm p. 397	scale p. 399
estivation p. 407	vertebrae p. 395
fin p. 399	

Fill in the blanks with the correct vocabulary word or words.

1. All chordates have a notochord, pharyngeal pouches, postanal tail, and a(n) _____.

2. The inactivity of amphibians during hot, dry weather is _____.

3. All animals with a constant internal temperature are _____.

4. Reptiles are _____ with scaly skin.

5. Jawless fish have skeletons made of a tough, flexible tissue called _____.

6. Reptiles lay _____.

7. The structure that becomes the backbone in vertebrates is the _____.

Checking Concepts

Choose the word or phrase that best answers the question.

8. Which animals have fins, scales, and gills?
A) amphibians **C)** reptiles
B) crocodiles **D)** fish

9. Which is an example of a cartilaginous fish?
A) hagfish **C)** perch
B) tuna **D)** goldfish

10. What fish group has the greatest number of species?
A) bony **C)** jawed cartilaginous
B) jawless **D)** amphibians

11. Which of these fish have gills and lungs?
A) shark **C)** lungfish
B) ray **D)** perch

12. Biological indicators include which group of ectothermic vertebrates?
A) amphibians
B) cartilaginous fish
C) bony fish
D) reptiles

Use the photo below to answer question 13.

13. Which kinds of reptiles are included with the animal above?
A) snakes **C)** turtles
B) crocodiles **D)** alligators

14. What term best describes eggs of reptiles?
A) amniotic **C)** jellylike
B) brown **D)** hard-shelled

15. Vertebrates that have lungs and moist skin belong to which group?
A) amphibians **C)** reptiles
B) fish **D)** lizards

16. How can crocodiles be distinguished from alligators?
A) care of the young
B) scales on the back
C) shape of the head
D) habitats in which they live

John Cancalosi/DRK Photo

Thinking Critically

17. **Infer** Populations of frogs and toads are decreasing in some areas. What effects could this decrease have on other animal populations?

18. **Explain** why some amphibians are considered to be biological indicators.

19. **Compare and contrast** the ways tunicates and lancelets are similar to humans.

20. **Describe** the physical features common to all vertebrates.

21. **Compare and contrast** endotherms and ectotherms.

22. **Explain** how the development of the amniotic egg led to the success of early reptiles.

23. **Communicate** In your Science Journal, sequence the order in which these structures appeared in evolutionary history, then explain what type of organism had this adaptation and the advantage it provided: skin has mucous glands; skin has scales; dry, scaly skin.

24. **Compare and Contrast** Copy and complete this chart that compares the features of some vertebrate groups.

Vertebrate Groups

Feature	Fish	Amphibians	Reptiles
Heart			
Respiratory organ(s)	Do not write in this book.		
Reproduction requires water			

25. **Explain** how a fish uses its swim bladder.

26. **Identify and Manipulate Variables and Controls** Design an experiment to find out the effect of water temperature on frog egg development.

27. **Classify** To what animal group does an animal with a two-chambered heart belong?

28. **Identify** why it is necessary for a frog to live in a moist environment.

Performance Activities

29. **Conduct a Survey** Many people are wary of reptiles. Write questions about reptiles to find out how people feel about these animals. Give the survey to your classmates, then graph the results and share them with your class.

30. **Display** Cut out pictures of fish from magazines and mount them on poster board. Letter the names of each fish on 3-in × 5-in cards. Have your classmates try to match the names of the fish with their pictures. To make this activity more challenging, use only the scientific names of each fish.

Applying Math

Use the table below to answer questions 31 and 32.

Fish Species

Kinds of Fish	Number of Species
Jawless	45
Jawed cartilaginous	500
Bony	20,000

31. **Fish Species** Make a circle graph of the species of fish in the table above.

32. **Fish Percentages** What percent of fish species is bony fish? Jawed cartilaginous? Jawless?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. What are fins attached to?
A. ectoskeleton **C.** endoskeleton
B. notochord **D.** spine

2. How many chambers does a fish heart contain, and does it carry more or less oxygen than other types of hearts?
A. two, less **C.** three, less
B. four, less **D.** four, more

Use the photo below to answer question 3.

3. What type of fish is shown in this picture?
A. bony
B. jawed cartilaginous
C. large-mouth bass
D. jawless

4. How do amphibians exchange carbon dioxide and oxygen?
A. lungs only **C.** gills only
B. lungs and skin **D.** lungs and gills

5. How do frogs and toads hear?
A. eardrum
B. tympanic membrane
C. skin
D. tongue

6. Fish and amphibians do not have this type of egg so they must reproduce near water.
A. external **C.** porous
B. membranous **D.** amniotic

Use the photos below to answer questions 7 and 8.

7. What is the developmental process shown in this diagram?
A. metamorphosis
B. respiration
C. ectotherm
D. asexual reproduction

8. Where does this transition take place?
A. land to air **C.** water to land
B. air to land **D.** land to water

9. What is one way to distinguish a crocodile from an alligator?
A. the shape of the snout
B. number of eggs in nest
C. size of teeth
D. placement of nostrils

10. What are turtles missing that all other reptiles have?
A. hair
B. three-chambered heart
C. teeth
D. shelled eggs

Test-Taking Tip

Marking on Tests Be sure to ask if it is okay to mark in the test booklet when taking the test, but make sure you mark all of the answers on your answer sheet.

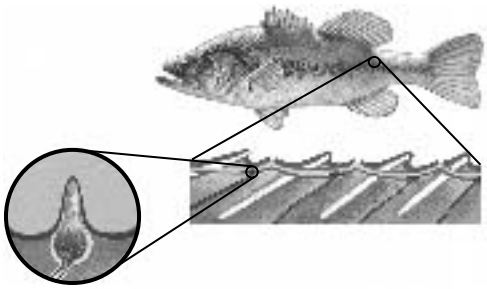
Question 6 Cross out answers you know are wrong or circle answers you know are correct. This will help you narrow your choices.

(cl)Tom McHugh/Photo Researchers, (others)Runk/Schoenberger from Grant H

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the illustration below to answer question 11.



11. Describe the body system of the fish shown in this diagram. Why is it important to the fish?

12. What organs do fish have for the exchange of carbon dioxide and oxygen? How does the exchange take place?

13. How does a fish's swim bladder regulate its depth in water?

14. What is the difference between hibernation and estivation?

15. As an amphibian goes through metamorphosis, how do their heart and lungs change?

16. What is one possible reason for the decline in the number of reptiles in swamps and coastal areas?

17. What is the relationship between the number of young produced and the amount of care given by the parents in fish, amphibians, and reptiles?

18. How do snakes hear?

19. Are reptiles endothermic or ectothermic? Can reptiles modify their body temperature?

20. During chordate development, what structures originate from the nerve chord?

Part 3 Open Ended

Record your answers on a sheet of paper.

21. Describe the composition and function of fish scales.

22. How did amphibians evolve and why were they the dominant land animals for a period of time?

23. Compare and contrast the circulatory systems of fish, amphibians, and reptiles. Which system provides the most oxygenated blood to the organs?

Use the illustration below to answer question 24.

24. Explain the composition and significance of the structure in this diagram.

25. Discuss the structure of a turtle's shell and what other body parts are attached to it.

26. What are two classifications of how organisms regulate body temperature? How does regulation of body temperature help to determine the climate in which an organism is found?

27. What are pharyngeal pouches and what animal group has them at some point during development? How has their function changed over time?